APPROACHES OF

CLOSE TO NATURE SILVICULTURE

IN

SITKA SPRUCE PIONEER PLANTATIONS

IN

IRELAND

PROF. HANS-JÜRGEN OTTO

PRO SILVA is a European Federation of Foresters
which advocates forest management based on natural processes.

Table of Contents

PRO SILVA was founded in Slovenia in 1989,
PRO SILVA IRELAND was founded in 2000.

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Prof. Hans-Jürgen Otto

Co-founder and former President of Pro Silva Europe.
Co-founder of Pro Silva Germany.

Prof. Hans-Jurgen Otto during a Pro Silva Ireland trip to Lower Saxony, Germany, Sept, 2001

Prof. Hans-Jürgen Otto studied Forestry science at the university of Göttingen, Munich and Nancy. After completing his Doctorate he became a consultant to the Ministry of Food, Agriculture and Forestry in Hanover, where he advised on the ecological fundamentals of silviculture, forest protection, planning and research for over 20 years.

During this time the state owned forests under his control were managed using close to nature silvicultural principles, returning record profits while their capital value appreciated. These permanent forests stand now as a testament to his intimate understanding of forest ecology and economics and his vision as a forester.

After qualifying as a university lecturer in 1984 he has taught Forest Ecology at the University of Göttingen and at the University of Tharandt. He has visited many parts of the world in order to further study Forest Ecology.

Prof. Hans-Jürgen Otto has been a guest of Pro Silva Ireland on three occasions. In December 2003 he had a sudden cardio arrest as he returned from one of his many forestry trips abroad and this has left him severely effected. He is often in our thoughts and, of course, in our forestry discussions.

1. Pioneer forests

In natural forest dynamics without human influence a successional pioneer stage means the new beginning of forest life after a large scale disturbance, for instance a storm throw. This is said to be a secondary succession, because a forest or some other vegetation has existed before. In nature many strategies of resettling open areas exist. They are in most cases very effective and at the beginning very quick. A cover of ground vegetation may precede the real pioneer stage with tree species. This stage is the "non-forest-stage". Within this stage one will meet different phases of plant species, following a phase pattern from lichens via mushrooms and mosses to grass species, herbs, ferns, and shrubs. The succession of the earliest phases may be run through in less than one year. So, from an ecological perspective, there are no "weeds" in nature, but strategies to colonise "wounded" open areas in a short period.

The pioneer stage, in which tree species begin to settle, can also be subdivided in different phases, in which different species will dominate. The main common characters of all pioneer tree species are:

- light demanding or at least tolerating full light;
- effective seed production, that means regular seed crops;
- rich or abundant crops;
- very good long distance dispersal of seeds;
- successful germination of large numbers of seeds;
- well developed capacities to germinate in different ground vegetation layers and other difficult circumstances.

Pioneer species are also sprinters. Their youth growth is fast. So in a short period they become dominant in competition with non-tree species, pushing them more or less out of the ecosystems. Later on, successions move to intermediate and sub-climax stages, which may

Sitka spruce stand with large gap - a chance for a mixture of species. Lake District, England, July 1994.

also have varying phases, until the climax forest is reached. This final forest is the composition of trees in a certain forest association, which is best adapted to the surrounding environmental growth features: climate, soils, and to the impact of special disturbance patterns.

Sitka spruce plantations can be considered to be a forest pioneer vegetation, although they are not natural. But they are set into open areas, covered by non-tree vegetation. Irish and British foresters have accomplished an outstanding operation of land cultivation, which is in some basic achievements similar to North German reforestation of heath land, which began 200 years ago: soils have been covered; wind and water erosion have been stopped; valuable timber production was started; a humus layer began to be forced; and some first modest improvements of increasing biodiversity could be observed; sometimes, a former excess of seepage water on special sites was diminished when the water-pump of trees began to consume more water. These are positive results which can hardly be over emphasized.

However, Sitka spruce and Norway spruce are not considered to be typical pioneer species. Despite this both have comparable effective regeneration strategies, relatively good and frequent seed crops, satisfying seed dispersal strategies, good germination properties and fast growth. And both species can tolerate the full light situation of open areas.

2. Advantages of conventional forestry

Traditional Sitka and Norway spruce plantations have been achieved by planting open areas, with or without preceding soil preparation, with or without preceding weed control. Different assortments of plants, coming from nurseries, have been planted with different numbers of plants and normally with an accurate regular spacing. The plantations have been tended, thinned, and finally harvested in a calculated commercial period. The final harvesting method has been clearfell, often on larger areas. This silvicultural method, imitating agricultural methods of cereal-fields, was successful during several generations of stands. And it cannot be excluded, that on some stable sites this might again continue for some time. Its main advantages are: easy to plan; easy to execute; easy to calculate; easy to control; not needing sophisticated techniques. In fact, everybody can do it.

3. Disadvantages and risks of conventional forestry

However, in German Norway spruce forests some disadvantages of this traditional forestry were revealed. The longer the above mentioned methods were practiced and the more exactly the same operations were executed over many generations of succeeding stands on the same sites with the same conifer monocultures, the more evident these disadvantages have become. These disadvantages are:

- **Poor stability against the impact of storm disturbances.**

In German Norway spruce plantations, the former regular age class distribution, which was maintained during the 19th century, has been increasingly disturbed, where the same plantations were repeated on the same soils. From the beginning, five age classes were planned, each covering a planning period of 20 years, with a total rotation time of 100 years. In theory the five age classes should behave consistently with the same volumes. But this is no longer true. Instead they became "stairs", with steeper and steeper steps. The 5th age class (age 81 to 100 years) has today a volume of 1/5 of what should be there. The rest was destroyed by storms and insects before becoming mature. The explanation for this phenomenon is the following: Old trees and stands bring a heavy weight on the soils. We measured in a 60 year old Norway spruce stand a total weight of about 600 t/ha. In Sitka spruce it will probably be higher. When spruces produce a shallow root system, they will stamp the soils when swinging in a permanently blowing wind. The result has been modification of soils by increasing compactness, minimising aeration, and forcing the trees to make even shallower rooting. In Germany we are quite sure, that spruces are deteriorating soils, because they have a "lazy" rooting, and more than one or two generations of spruce without stabilising mixtures are considered to be risky.

• **Spruce plantations produce acid humus.** The turnover and recycling of nutrients in the humus layers is not perfect, often it is seriously inhibited. There is no sustainable soil protection, no guarantee for soil fertility on the same level with repeated generations of spruce monocultures.

• **Spruce plantations are not really good for biodiversity.** Ground vegetation is often poor or absent.

• **The high risk of storm hazard produces uncertain economies.**

• **The clearfelling systems in spruce plantations do not provide a regular income.**

• **The system produces too large a percentage of poor timber, and too low proportions of valuable and of large timber.**

• **The regular spacing of planting, tending and thinning is one of the causes of instability.**

• **The system is very intensive considering the required inputs of energy, man-power and money.** From the plantations until the final clearfelling, one intensity has as a consequence on the next one.

4. Possibilities for changing silvicultural methods in Sitka spruce forests

What can be done to evolve the traditional silvicultural techniques in order to obtain safer, more biodiverse forests, providing a sustained regular income at the least costs to the forest owner, and minimising natural and market risks?

Windthrow gaps and regeneration in Scots Pine stand

The possibilities can be subdivided into measures where:

- Sitka spruce silviculture shall be continued;
- Sitka spruce shall be replaced by other species.

4.1 Site Mapping

A correct analysis of what are the potentialities of species choice under local environmental conditions requires site mapping.

Site mapping is a basic requirement.
It provides: Which species can be recommended; which species should not be chosen; definition and map delimitation of non stable soils; information over site-adapted soil preparation methods; site-adapted recommendations for fertilising.

Site mapping methods are:
A climatical analysis (macro-climate and micro-climate in relation to reliefs, aspects, exposure and altitude).
Soil analysis with chemical lab analysis; definition of "site types"; delimitation of these site types by field mapping; presentation in a site map of scale 1:10 000; description of each site type with the conclusion

of the above cited recommendations. No forest enterprise in Germany is working without site mapping. The basic investment costs per hectare are not low, but as sites do not change quickly, this investment is made once only.

4.2 Possibilities in existing Sitka spruce stands

In existing Sitka spruce stands, one can see three approaches:

- methods increasing the physical stability in non-mixed stands;
- methods of natural regeneration, making profit from pioneer situations;
- methods of creating mixed stands.

4.2.1 Physical stability of Sitka spruce stands

Individuals forming biogroups send their main roots towards their partner. Lake District, England, Sept.,1995

All natural forests without human interventions have two patterns of ongoing stand growth: segregation and aggregation processes. Segregation or individualisation of individual trees occurs through competition. The more vigorous trees suppress and eliminate the less vigorous ones. Thus, all forests move from high stem numbers to low ones. Foresters are used to sustain this evolution by tending and thinning. But in natural forest, the result of this segregation process is never a stand with regular distances between trees. Denser and clearer parts subdivide these forests in a mosaic of different densities.

Merged roots have same phloem and xylem.

Some trees stay not only close together, but they begin to merge their roots. In such biogroups there is not only a mutual exchange of nutrients, but the trees hold each other against the impact of wind. In this way, natural forests are subdivided in a mosaic of more and less stable parts. This means that all risks will be diffused and so minimised. As a matter of fact, large scale wind-throw areas are an exception in virgin forests. The normal feature is a structure of smaller and larger gaps, and tree groups of varying density.

Windthrow gap and bio-group in Sitka spruce, Lake District, England, Sept., 1995.

In our traditional intervention methods, thinning operations have destroyed biogroups, when spacing "future trees" in equal distances and eliminating their competitors. As a consequence stand stability against storm impact is changed for the worse.

Sitka spruce and Norway spruce are well grouping species. Respecting biogroups can be a contribution to better stand stability. The practical intervention methods should be:

• Identification of the existing biogroups before thinning.

• Where there are no biogroups, thinning as usual, favouring the formation of large crowns with green branches on 1/3 to 1/2 of the trees height thus bringing down the centre of gravity in the stems. This should be done early in the stands life.

• Conservation of biogroups. Groups should be considered as 'thinning units'. This means, that thinning should liberate the aggregation of the crowns of a group, taking off competing trees in the neighbourhood of this aggregation, as one is used to do in favour of single trees.

• When site mapping has shown sites (often these are only micro-sites measurable in square meters) with lower stand stability, spruces should no longer be planted, because such areas are normally the starting point of wind-throw even into more stable parts of the whole stand. These gaps should be planted with alder.

4.2.2 Stream valleys

In order to introduce some landscape structure into large Sitka spruce stands and in order to increase the stability of a large conifer area, it is useful to avoid spruce plantations in stream valleys. These are very often moist areas and can be the starting point of storm hazards. The shadow given by spruces and their needle-fall is a disaster for the life forms of streams and their interactions. A strip of 20 m both sides of the stream or even more should be planted with alder (*A. glutinosa* only), and on better sites, with ash and sycamore. In the Harz mountains (Norway spruce) we even took away existing trees near streams, an easy operation with large positive effects and with no visible increase in instability.

4.2.3 The handling of natural disturbances for natural regeneration

Storms, when they are not too strong, are good site mappers. They throw first those trees, which are located on less stable parts of the soils. Perhaps the remaining trees after a storm-throw have been luckier than their fallen neighbours. But a more consistent factor is the stability of micro-sites, which allow a deeper rooting. So it can be said, that the artificial enlarging of wind-throw gaps is a mistake. In a way, one can say, that the repeated impact of storms is a permanent process of increasing relative stability, which should not be influenced by excessive

Performing group of Norway Spruce in natural regeneration, Ossiach, Austria, April 1996 human activities. The borders of such gaps can eventually be the new borders of stability. The next point is, that wind-throw gaps are the starting point of natural regeneration. The formation of gaps in natural forest is a continuous process of stand openings in time and space. In managed forest, no human intelligence has yet found an effective method to avoid this dynamic process. So you have to live with it and make the best of it. The result will be a pattern of irregular regenerations with different heights and sizes. This is welcome, because the mosaic pattern of different densities increases and openings, tree ages and heights is an element of stability and increases the capacity to react after disturbance events of the whole forest unit. The larger a homogeneous situation, the larger will be the scale of disturbances. Small scale variations in the stand composition will disperse the impact of gales.

Norway Spruce stand structuring by single tree harvest diameter thinning. Natural regeneration of broadleaf species (rowan, birch, beech). Harz, Germany, May 1993.

4.2.4 Plantations on clearfelled areas

Open fields do not have good microclimate. This situation can easily inhibit the germination of natural regeneration and young saplings can dry out in a few dry summer days. This often happens in thick raw humus layers, which easily dry in hot summer periods. Young tree plants on open areas may also suffer from the competition of weeds, the impact of sea salt spray and from high stagnant seepage water after the destruction of the old stands water pump, and from late frost. The following measures can help:

- **Artificial draining of moist mineral soils and peatland,** until the water pump of the new stand begins to work;

• **Liming and fertilising;**

• **Soil preparation in order to open the mineral soil.** Wood debris and the humus should be conserved as much as possible, and micro-structures on the areas surface should not be graded. They provide hidden micro-niches, where wind impact is lower, the relative humidity is higher and late frost lower;

• **Planting "little shelters"**: alder 3x3m or 4x3m (or birch, ash, pine species, larch). The plantation should be done 2 years before planting Sitka spruce or together with it. All alders are good: *A. glutinosa*, *A. rubra* and *A. incana*. They minimise evaporation losses, create a new micro-climate, lower late frost risks and bring a better deep rooting, therefore increasing stand stability. These little shelters can be removed later with thinnings, disappear by themselves, or they can be used as commercial species. In Germany, alder of about 40 cm dbh or thicker gets 250 to 600 Euro/m3.

4.2.5 Commercial mixture species

Soils don't have the same properties. So again the categorical imperative of Silviculture is to respect the site by selecting conforming plantations. Tree species have developed different site adaptations. In consequence the main objective must be to put the right tree on the right soil; the same has to be said for mixtures.

The creation of mixed stands follows long-term experiences. Site conforming species selection and well adapted mixtures are an element of better stand stability, of better ecosystem elasticity after disturbances, of an improved economic income, of higher biodiversity, and often they provide better recreational values.

Which tree species could perform these objectives in Sitka spruce stands? The question is not easy to answer for Irish growth conditions. Some long-term experiences from the German North sea coast might be allowed to be brought into discussion. This coast is also a windy coast (Mean wind speed 6 to 8 m/sec/y). The following proposals can be articulated:

• **Exclude all non stable sites** (high seepage water levels in soils, heavy clays, and others) from Sitka spruce plantations.

The following mixture species can be recommended as mixture trees in Sitka spruce stands:

a**) Ash** (*Fraxinus excelsior*): A most interesting species in real mixtures with Sitka spruce could be ash. It is an extremely deep-rooting tree, has a very stiff crown, which is not harmed by permanently blowing winds and by sea salts, it has a comparable growth rhythm with Sitka spruce and can produce very valuable timber. With these characteristics it is present near all coasts of temperate Western Europe, even replacing beech near the coast lines. The main condition is that ash should be chosen on soils of more than pH 5.0. And as a matter of fact it cannot follow Sitka spruce on peat land.

b) Sycamore (*Acer pseudoplatanus*): The same characteristics are valid for sycamore, but the risk of grey squirrel damage seems to be higher. Both, alder and sycamore as well have good rooting and are stabilising species.

c) Alder (*Alnus glutinosa, A. rubra*): Alders can be commercial species with good perspectives in future markets, perhaps a bit lower in value than ash and sycamore. Their deep rooting, independent of soil aeration, can provide a natural nitrogen supply to soils, and their very good humus decomposition, the light and warmth which are brought into the stands are tremendous advantages. Normally, and mainly with ash, the mixture form should be a group, not a single tree mixture, which would be more difficult to manage. But alder can be mixed as single tree or in alternating lines with Sitka.

d) A stabilising conifer species could be *Abies grandis*. But there are no known examples of such mixtures. Its deep rooting even on peat land is certainly a stabilising factor. Its market value however is low.

4.3 Species change: Recommendations near sea coasts

The potential of different species choices are summarised in Table 1 (Broadleaves) and Table 2 (Conifers). Its basis is the situation near the North sea coast in Germany, as we experienced it since the first plantations 200 years ago.

This experience must be checked for Irish conditions and eventually modified.

Table 1: Site conform species choice near coasts: site conditions and species behaviour

Broadleaves

Species	Native	Adaption to climate	Site properties	Light demanding	Crown adaption to wind
Ash (Fraximis excelsior)	yes	very good	pH 5.0+	high	v. good
Sycamore (Acer pseudoplatanus)	no	medium	ph 4.5+	medium	bad
Sessile Oak (Quercus petraea)	yes	good	pH3.5+	high	good
Penduncolate Oak (Q. penduncolata)	yes	good	pH3.0+	high	good
Red Oak (Q. rubra)	no	good	pH4.0+	medium	medium
Beech (Fagus silvatica)	no	good	pH3.5+	low	v. bad
Birch (Betula pendnia)	yes	good	pH3.0+ (on peat)	very high	medium
Birch (Betula jubescens)	yes	good	pH3.0+ (on peat)	very high	medium
Rowan (Sorbus aucuparia)	yes	very good	pH3.0+	high	good
Cherry (Prunus avium)	yes	medium	pH4.0+	very high	medium
Wild Service (S. trominalis)	no	poor to medium	pH5.0+	high	v. good
Black Alder (Alnus glutinosa)	yes	very good	pH3.5+	high	v. good
Grey Alder (Alnus incana)	no	very good	pH3.04-	high	good
Red Alder Alnus rubra)	no	very good	pH3,(R pH3.0+ on peat)	high	good
Willow (Salix caprea)	yes	good	pH3.0+ (on peat)	high	good
Willow (Salix aurita)	yes	very good	pH3.0+ (on peat)	high	good

Rooting	Natural regen.	Youth growth	Humus decomp.	Browsing risk	Auxiliary species	Comm. species
very good	good	very fast	good	strong	no	yes
very good	good	very fast	good	medium	no	yes
good	medium	fast	medium	strong	no	yes
good	medium	fast	medium	strong	no	yes
good	good	very fast	medium	medium	no	yes
bad	medium	slow	medium	medium	no	yes
bad	very good	very fast	bad	low	yes	yes
bad	good	very fast	bad	low	yes	no
good	good	very fast	very good	strong	yes	no
good	good	very fast	very good	strong	no	yes
good	bad	slow	good	strong	no	yes
very good	bad	fast	very good	low	yes	yes
very good	good (root sprouts)	fast	very good	low	yes	yes
very good	medium	fast	very good	low	yes	yes
bad	good	fast	very good	strong	yes	no
bad	good	fast	very good	strong	yes	no

Table 2: Site conform species choice near coasts: site conditions and species behaviour

Conifers

Species	Native	Adaption to climate	Site properties	Light demanding	Crown adaption to wind
Douglas Fir (Psuedotsuga menz.)	no	medium to bad	pH 3.5+	medium	bad
Black Pine (P. nigra austriaca)	no	very good	pH 3.0+	high	v. good
Scots Pine (P. sylvestris)	yes	good	pH3.0+	high	medium
Weymouth Pine (P. strobus)	no	good	pH3.0+ (peat)	medium	medium
Western Red Cedar (Thuja plicata)	no	very good	pH3.5+ (peat)	low	good
Western Hemlock (Theterophylla)	no	very good	pH3.0- (peat)	very low	v. good
Jap. Larch (Latrix homolepsis)	no	good	pH4.0+	very high	medium to good
Silver Fir (A. alba)	no	good	pH4.0+	very low	bad
Amabilis Fir (A. amabilis)	no	good	pH4.0+	very low	?
Grand Fir (A. grandis)	no	good	pH3.0+ (peat)	high	v. good
Noble Fir (A. procera)	no	good	pH4.0+	high	good

Rooting	Natural regen.	Youth growth	Humus decomp.	Browsing risk	Auxiliary species	Comm. species
medium to bad	good	very fast	good	low	no	yes
very good	bad	fast	bad	low	yes	yes
medium	good	fast	bad	low	yes	yes
bad	very good	very fast	bad	low	no	yes
medium	bad	fast	good	?	no	yes
good	very good	fast	bad	?	yes	yes
medium	medium	very fast	very bad	low	yes	yes
very good	very good	slow	good	very strong	yes	yes
very good	?	slow	?	very strong	yes	yes
very good	poor	fast	medium	medium	yes	yes
very good	poor	medium	medium	?	yes	yes

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PRO SILVA Forestry Principles

PRO SILVA promotes forest management strategies which optimise the maintenance, conservation and utilisation of forest ecosystems in such a way that the ecological and socio-economic functions are sustainable and profitable. The general approach to management which is advocated by PRO SILVA, includes market and non-market objectives, and takes the whole forest ecosystem into consideration.

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PRO SILVA IRELAND
36 Fitzwilliam Square, Dublin 2, Ireland
E:: prosilva@eircom.net, W:: www.prosilvaireland.org